Space Weather Technical Forecast

Issued on Tuesday 7 January 2025 at 13:00 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Further M-class flares likely. Active electron fluence becoming likely.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate with one M-flare observed from AR3947, peaking at M4.8 at 06/1624 UTC. There are now eight sunspot regions on the visible disc, with AR3939 and AR3941 rotating off the west limb, AR3949 fading, but a small new region developing north of AR3947. AR3947 remains the largest and most magnetically complex region, responsible for the majority of recent activity. However, whilst there has been some minor spot emergence, the overall size and complexity of the group has reduced. The remaining regions on the disc all appear smaller and simple at the present time.

An M4.8 flare, peaking at 06/1624 UTC, with associated coronal dimming and Type II and IV radio emissions from AR3947 would normally be considered likely to have resulted in a CME. However, nothing significant has been visible in coronagraph imagery, so confidence is low regarding this event. A CME arrival from this cannot be ruled out, but appears unlikely.

Solar Wind / Geomagnetic Activity: The solar wind environment was enhanced due to the ongoing, but slowly declining connection to CH05/+, with a weak CME arrival around 07/0410 UTC. Solar wind speeds were elevated to strong, between roughly 500-600 km/s. Density was near average throughout. The Interplanetary Magnetic Field, Bt, was weak, briefly reaching moderate after the CME arrival peaking at 8nT. The north-south component, Bz, varied weakly between +/-7nT. The Phi angle was mostly positive (away from the Sun), becoming variable after 07/0445 UTC. Geomagnetic activity was Quiet to Unsettled (Kp 2-3).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES-18 was below the S1/Minor Storm threshold, but slightly above normal background levels (on a declining trend).

High energy electron flux (greater than 2MeV) at GOES16 was at Moderate to diurnally High levels with the associated 24 hr fluence staying below the Active threshold, but on a rising trend. The 07/0000 UTC fluence observation was 5.79e7 integrated pfu.

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Four-Day Space Weather Forecast Summary

Solar Activity: Activity is likely to be Moderate, with a slight chance of isolated X-flares, primarily from AR3947. Given that AR3947 has been declining in complexity, the flare risk is reduced compared to the previous forecast.

Solar Wind / Geomagnetic Activity: A CME arrived overnight as a weak glancing blow, although it has increased the wind speed again to strong levels. An M4.8 flare, peaking at 06/1624 UTC, would normally be considered likely to have resulted in a CME. However, nothing significant has been visible in coronagraph imagery, so confidence is low, but a CME arrival from this cannot be ruled out. Earth has been connected to a high speed stream associated with CH05/+. Solar winds were declining slowly until the CME arrival, but the gradual decline is likely to resume, perhaps coming down to background or slightly elevated levels in the next few days. The next coronal hole enhancement is possible from CH07/+ later on Day 4 (10 Dec), but speeds are unlikely to be much more than 400km/s.

Geomagnetic activity is expected to be mostly Quiet to Unsettled. There is a slight chance of Active to G1/Minor Storm conditions on Day 1 (07 Jan) with the current strong wind speeds, and again later in the period with CH07/+ onset and uncertainty regarding the CME forecast.

Energetic Particles / Solar Radiation: GOES18 high energy proton flux is below the S1/Minor Storm threshold, but slightly above normal background levels (on a declining trend). There is a slight chance of exceeding the S1/Minor Storm threshold during the period.

GOES16 high energy electron flux is currently varying between Moderate and diurnally High levels. Electron flux is likely to see further peaks of High levels during this period. The associated 24-hour fluence is currently just below the Active threshold on a rising trend. Active fluence becomes likely during this period.

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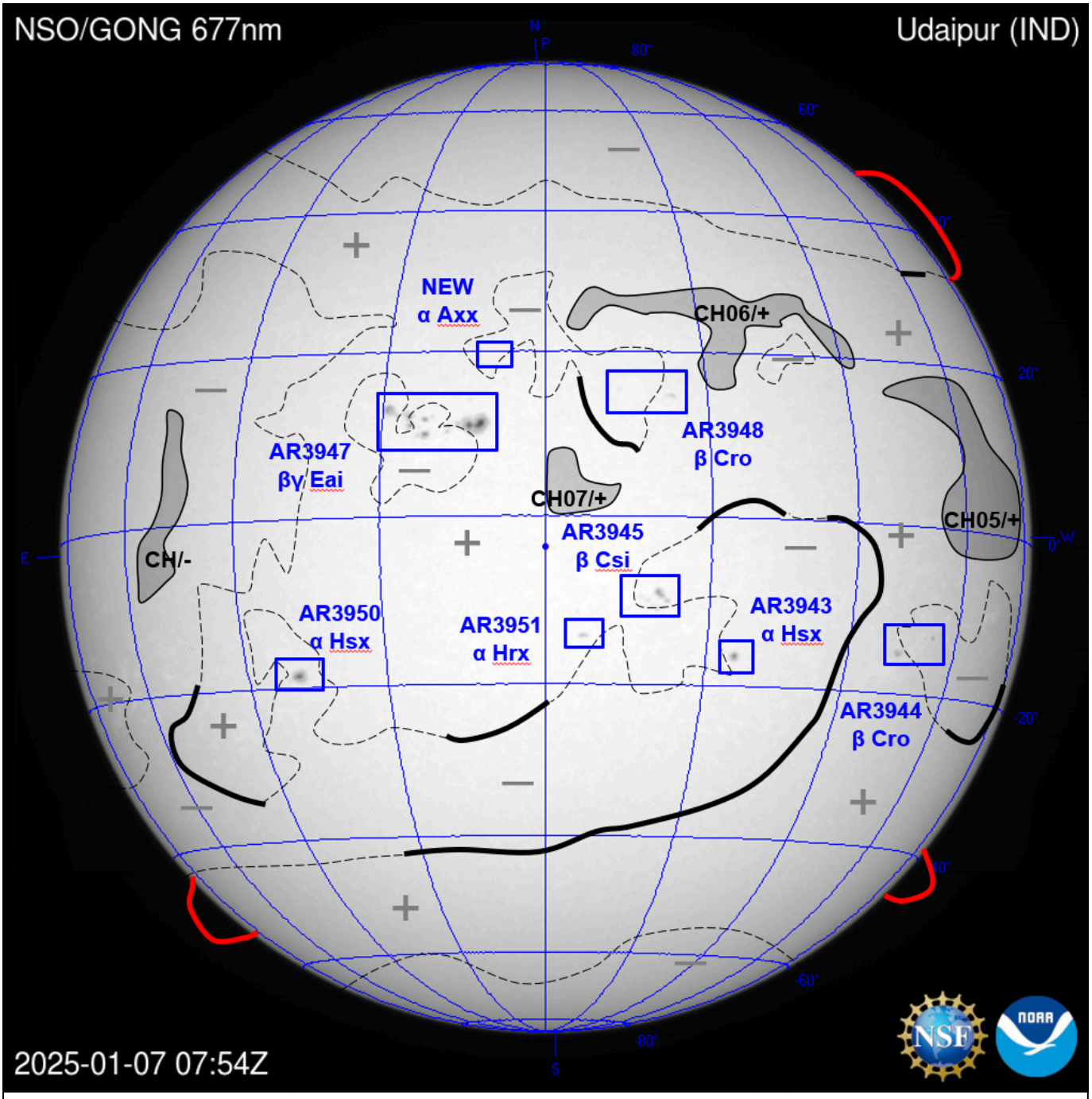
Figure 1: Solar synoptic map, valid at 07/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

Two CMEs which occurred from AR3939 in association with C-flares at 04/1444 and 04/1827 UTC arrived overnight as a weak glancing blow, although it has increased the wind speed again to strong levels. An M4.8 flare, peaking at 06/1624 UTC, with associated coronal dimming and Type II and IV radio emissions from AR3947 would normally be considered likely to have resulted in a CME. However, nothing significant has been visible in coronagraph imagery, so confidence is low regarding this event. A CME arrival from this cannot be ruled out, but appears unlikely.

Earth has been connected to a high-speed stream associated with CH05/+ in the northwest of the solar disc since 04/1400UTC. This coronal hole was originally a larger hole consisting of CH05/+ and CH06/+ which has since been split into two. Solar winds were declining slowly until the CME arrival, but the gradual decline is likely to resume, perhaps coming down to background or slightly elevated levels in the next few days. The next coronal hole enhancement is possible from CH07/+ later on Day 4 (10 Dec), currently located near centre disc in the Sun's northern disc. This feature is also recurrent from the last rotation in December and gave speeds of near 450km/s. By comparison, the coronal hole now appears smaller, and potentially slightly weaker than last month, so speeds are perhaps more likely to be around 400km/s.

Geomagnetic activity is expected to be mostly Quiet to Unsettled. There is a slight chance of Active to G1/Minor Storm conditions on Day 1 (07 Jan) with the current strong wind speeds, and again later in the period with CH07/+ onset and uncertainty regarding the CME forecast.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	1	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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Figure 2: Enlil ensemble, with one or two members showing CME hits but overall CME arrivals are considered unlikely at present.

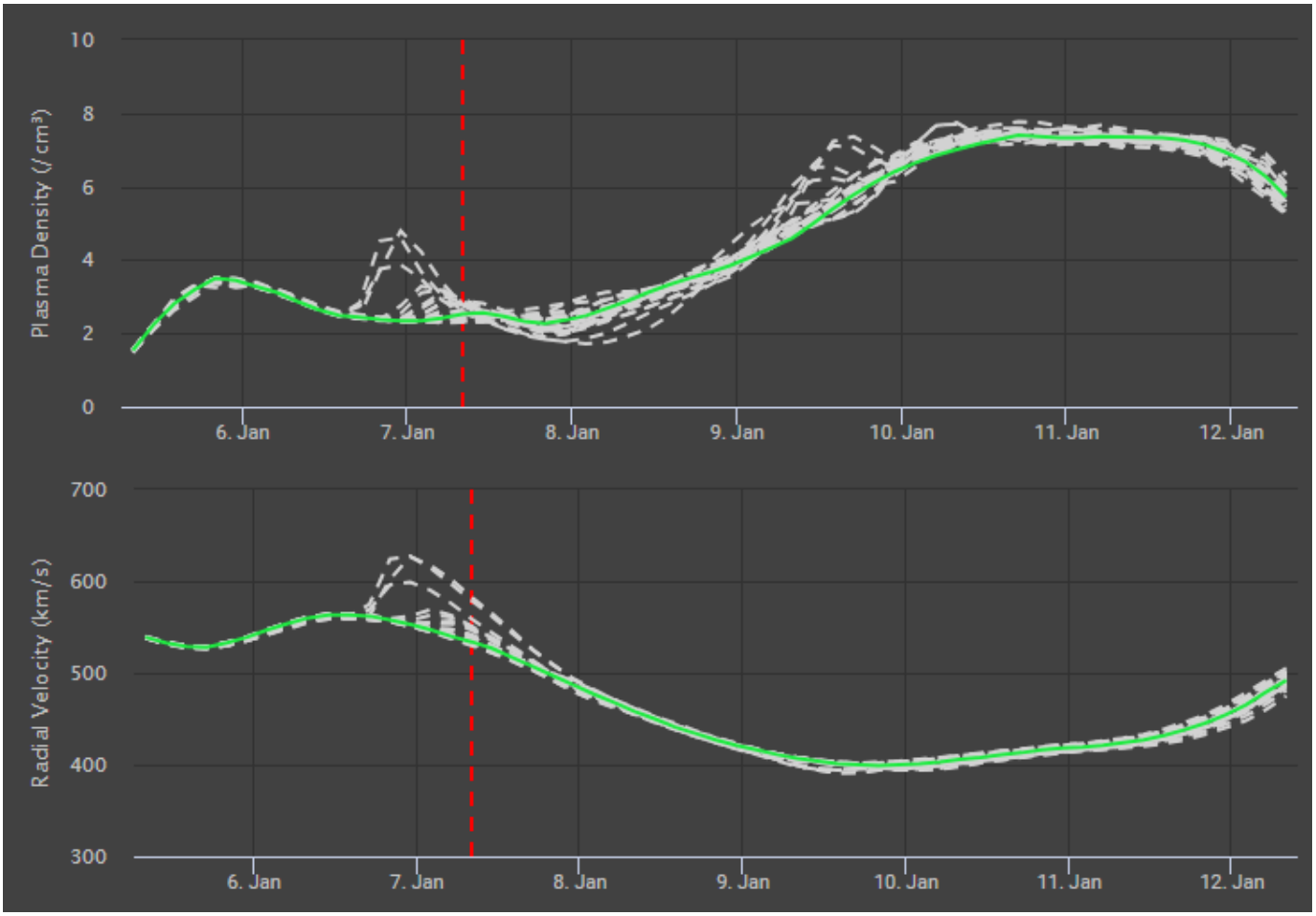

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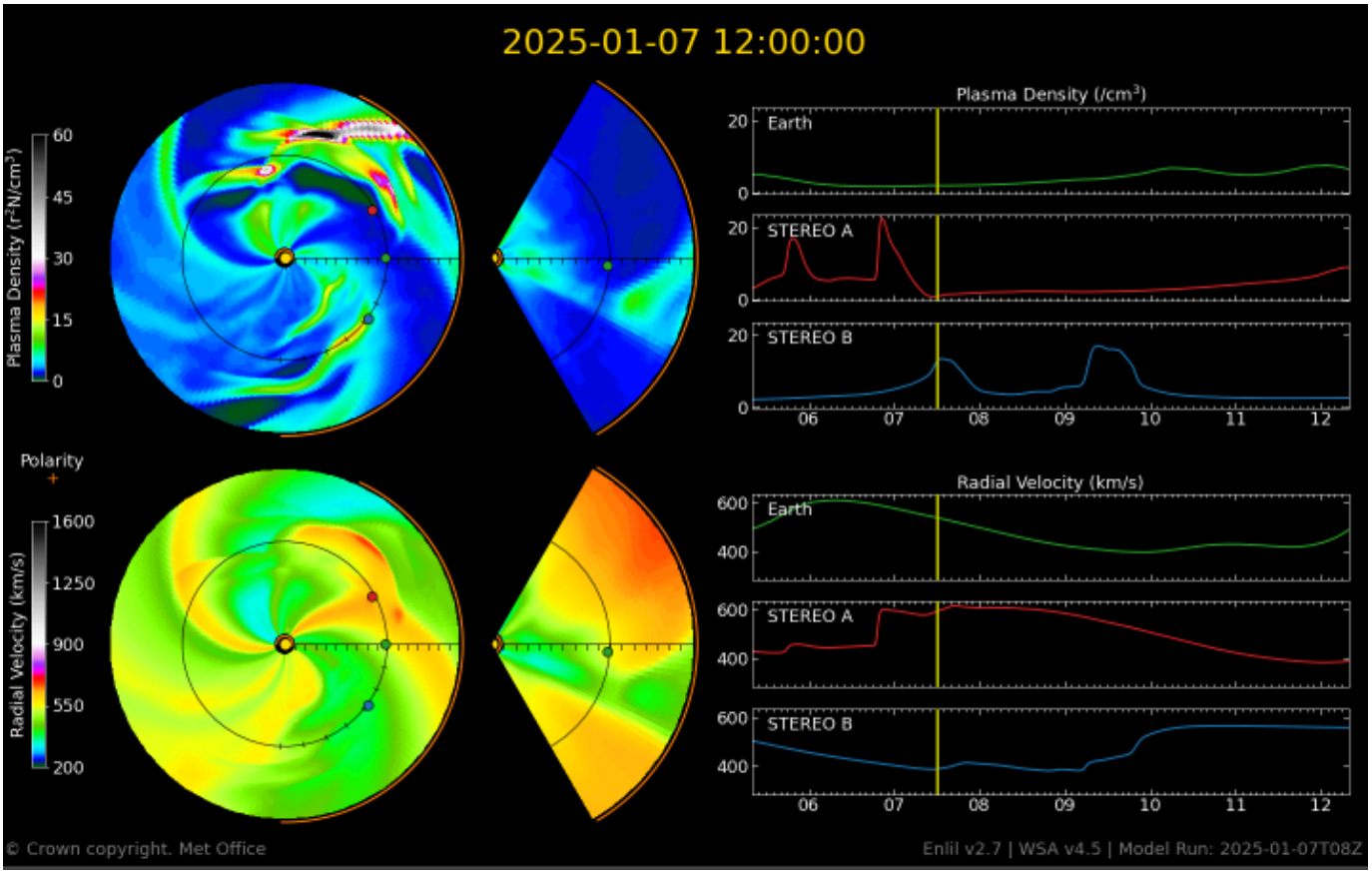
Figure 3: MOSWOC Enlil, showing a gradual decline in wind speeds which is reasonable guidance.



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Radio Blackouts - X-Ray Flares

Solar activity has been Moderate with one M-flare observed from AR3947, peaking at M4.8 at 06/1624 UTC.

There are now eight sunspot regions on the visible disc, with AR3939 and AR3941 rotating off the west limb, AR3949 fading, but a new region developing north of AR3947. AR3947 remains the largest and most magnetically complex region, responsible for the majority of recent activity. However, whilst there has been some minor spot emergence, the overall size and complexity of the group has reduced with the previous delta region pulling apart. The remaining regions on the disc all appear smaller and simple at the present time.

GOES-16 SUVI 171 imagery shows notable looping on the southeast limb with far-sided data showing a returning region (Ex-AR3930) likely to emerge in the coming 24 hours with a previous history of M-class flares.

Given that AR3947 has been declining in complexity, the flare risk is reduced compared to the previous forecast. Activity is likely to be Moderate, with a slight chance of isolated X-flares, primarily from AR3947.

X-Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 (M Class)**	Yes	60	60	60	60
Very Active	**R3-R5 (X Class)**	No	5	5	5	5

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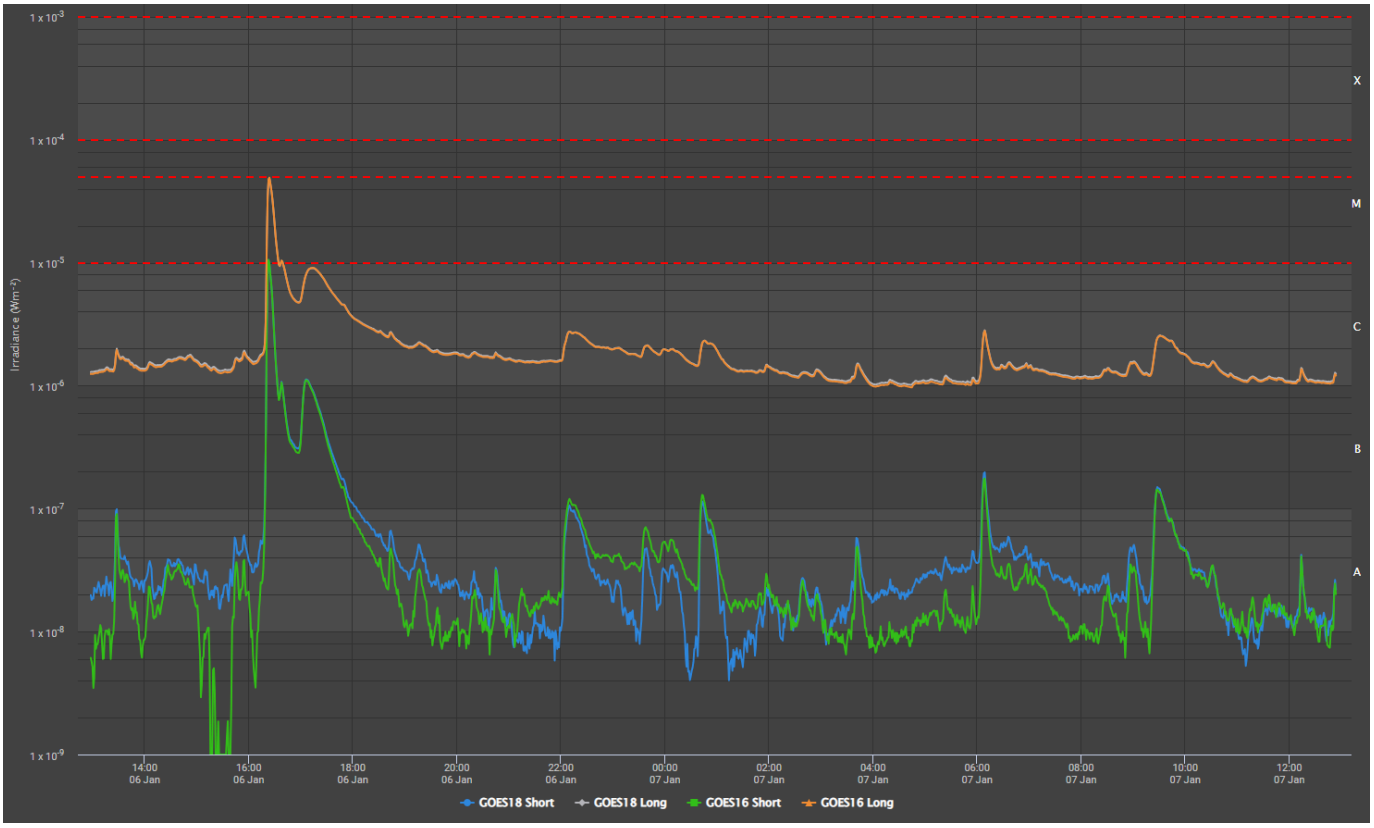
Figure 4: X-ray flux at GOES16 and 18, showing one M-class flare in the last 24 hours.



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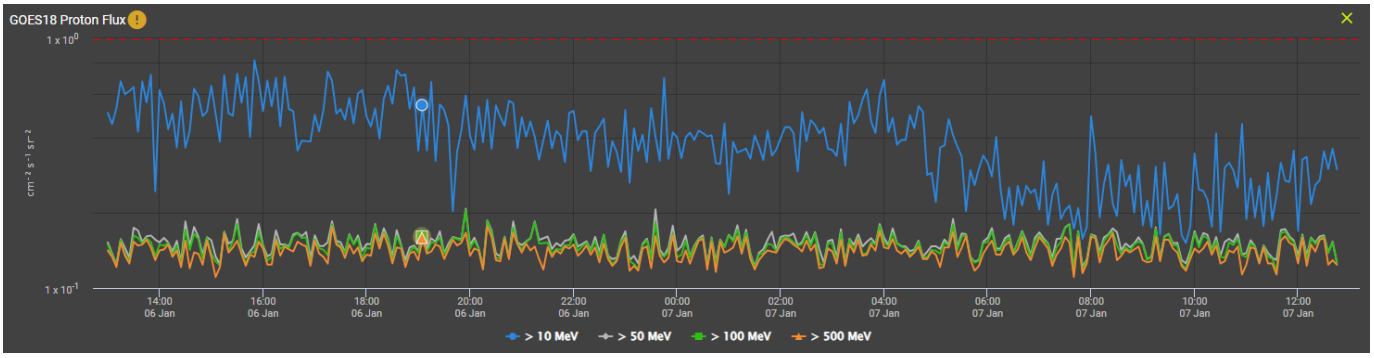
Solar Radiation Storms (High Energy Protons)

GOES18 high energy proton flux is below the S1/Minor Storm threshold, but slightly above normal background levels (on a declining trend), following an enhancement from the C9.1 flare from AR3939 on 04 Jan. There is a slight chance of further enhancements during the forecast period should any further significant flares occur in the western disc. As AR3939 rotates well away from the west limb in the coming days, AR3947 makes its way into the western hemisphere and into a more favourable location for proton enhancements to be detected at L1. However, given the recent simplification of AR3947, this risk is reduced a little later in the period.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	20	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: Protons flux at GOES18, which is on a declining trend well below the S1 threshold.



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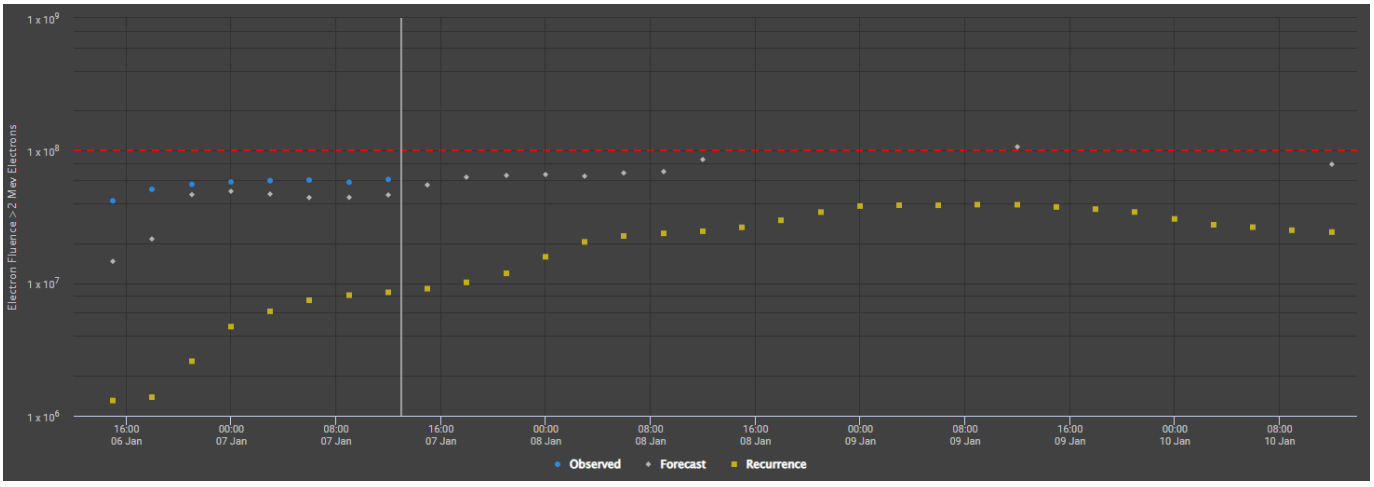
High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 is currently varying between Moderate and diurnally High levels following the connection to the high speed stream of CH05/+. The recent CME arrival caused a very slight drop out, but electron flux is recovering and is currently High. The recent strong solar wind speeds are likely to have increased the electron flux in the radiation belt, but majority of this will be suppressed below GEO by the strong winds. As wind speeds ease, there is the potential for a sharp increase in electron flux at GEO in the next couple of days. The onset of a weak high speed stream on Day 4 (10 Jan) from CH07/+ may suppress electron counts a little, but given the potentially weak nature of this feature, could also have minimal effect.

The associated 24-hour fluence is currently just below the Active threshold on a rising trend. Active fluence becomes likely during this period.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	30	50	60	50
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 6: MOSWOC REFM, showing a rise just above Active, which is considered reasonable guidance.



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